# Engineering Polymers

## Joining Techniques Design Guide

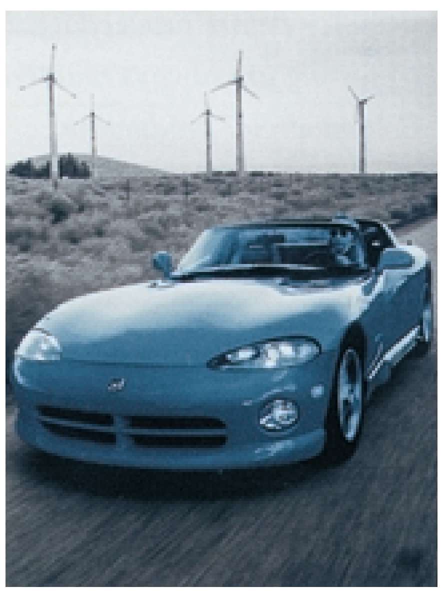
covestro

# DESIGNING FOR ASSEMBLY AND DISASSEMBLY

This manual is intended to help you successfully design and manufacture assembled parts made of:

- Makrolon® polycarbonate;
- Apec® high-heat polycarbonate;
- Bayblend® polycarbonate/ABS blend;
- Makroblend® polycarbonate blend;
- Texin®and Desmopan® TPUs

Thermoplastics can be joined successfully in a number of different ways, including mechanical fastenings, ultrasonic assembly, metal inserts, snap fits, electromagnetic and heat welding and solvent/adhesive bonding.



Thousands of parts are joined together in each automobile, such as the plastic components in this Dodge Viper.

To design good assemblies you must have:

- A working knowledge of the plastic resin you have selected;
- A fundamental knowledge of good joint design; and
- A thorough understanding of the purpose, geometry, ambient environment, chemicals, and mechanical loading which your assembly will encounter.

Additionally, a designer should design for disassembly, an important factor for serviceability that has gained increased emphasis because of plastics recycling considerations. Involving the designer, end user, materials supplier and molder or processor throughout a project will make the transition from concept to finished part much easier.

The techniques referenced in this brochure for joining parts made of Covestro engineering thermoplastic resins are those generally used in the industry. In those special cases where a technique should be modified for a specific Covestro resin, a note will be included in the text. For property and applications information, please go to our website: *www.plastics.covestro.com.*

## GUIDELINES FOR JOINING TECHNIQUES

*Sometimes you will have to assemble two or more component parts to produce a complex part. Early in the development stage, designers need to consider how they will effectively join mating components into a functional unit. Joining techniques can offer a cost-effective, aesthetically pleasing, and structurally sound solution for designing and manufacturing intricate parts.*

*The following guidelines are rules of thumb for part assembly. Naturally, there are exceptions to all rules of thumb or times when two of them conflict. If this happens, talk with your joining equipment supplier and Covestro personnel for assistance before proceeding. Prototyping and part testing are always required before going to full commercial production.*

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## TECHNICAL SUPPORT

*Mechanical fasteners — screws, bolts and rivets — offer one of the least expensive, most reliable and commonly used joining methods for assemblies that must be taken apart a limited number of times. Common practices for using mechanical fasteners are discussed in this section.*

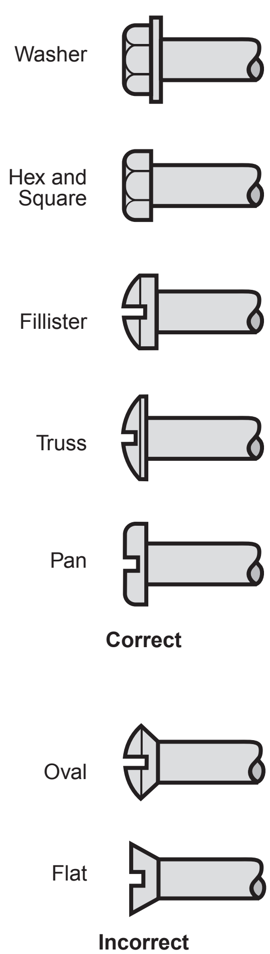
## SCREWS, BOLTS AND RIVETS

When using common mechanical methods for securing parts, pay special attention to the fastener's head. Conical heads, called flat heads, produce undesirable tensile stress in the mating parts and should be avoided (see figure 1). Bolt or screw heads that have a flat underside, called pan or round heads, produce less harmful, compressive stress. Use flat washers under both nut and fastener heads, because they help distribute the assembly force over larger areas (see figure 2).

Always make sure that there is sufficient distance between the edge of the fastener's hole and the part's edge. As a rule of thumb, this distance should be at least the diameter of the hole or twice the part's thickness, whichever is greater.

Additional clearance may be needed if your part has slotted holes for attaching large plastic panels to metal or wood frames to account for the differing coefficients of thermal expansion. See page 12 for a discussion of this topic.

**Figure 1**

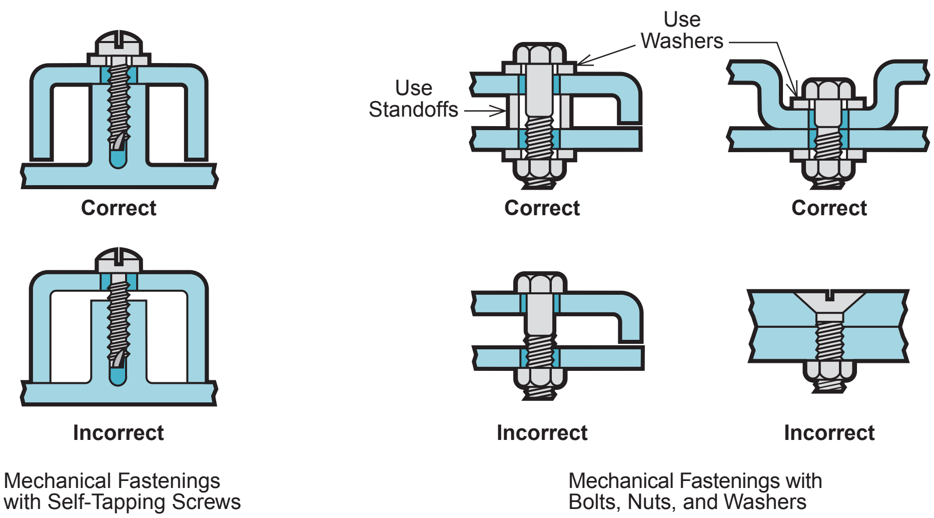



Common head styles of screws and bolts.

**Table 1** U.S. & Metric Threads

| Unified National Coarse (UNC) (Size) | Outer Diameter, US (in) | Nearest ISO Equivalent (mm) | Outer Diameter, ISO (in) |
|---|---|---|---|
| **1-64** | 0.073 | M1.8x0.35 | 0.071 |
| **2-56** | 0.086 | M2.2x0.45 | 0.087 |
| **3-48** | 0.099 | M2.5x0.45 | 0.098 |
| **4-40** | 0.112 | M2.6x0.45 | 0.102 |
| **5-40** | 0.125 | M3x0.5 | 0.118 |
| **6-32** | 0.138 | M3.5x0.6 | 0.138 |
| **8-32** | 0.164 | M4x0.7 | 0.157 |
| **10-24** | 0.190 | M5x0.8 | 0.197 |
| **12-24** | 0.216 | — | — |
| **1/4-20** | 0.250 | M6x1 | 0.236 |
| **5/16-18** | 0.313 | M8x1.25 | 0.315 |
| **3/8-16** | 0.375 | M10x1.5 | 0.394 |
| **7/16-14** | 0.438 | M11x1.5 | 0.433 |
| **1/2-13** | 0.500 | M12x1.75 | 0.472 |
| **9/16-12** | 0.563 | M14x2 | 0.551 |
| **5/8-11** | 0.625 | M16x2 | 0.630 |
| **3/4-10** | 0.750 | M20x2.5 | 0.787 |
| **7/8-9** | 0.875 | M22x2.5 | 0.866 |

**Mechanical Fastenings** **Figure 2**




## MOLDED-IN THREADS

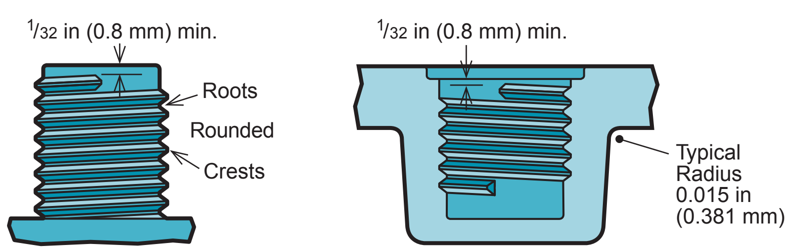
When your application requires infrequent assembly and disassembly, you can use molded-in threads for mating thermoplastic to thermoplastic parts (see figure 3). For easier mold filling and better part tolerances, avoid designing parts with threads of 32 or finer pitch. Do not use tapered threads, such as pipe threads, unless you provide a positive stop. Overtightening can cause excessive stress following assembly that can lead to part failure.

If possible, avoid molded-in threads when mating thermoplastics to metal. These materials have large differences in both stiffness and thermal expansion, and sharp edges of metal threads can also result in high stress in the thermoplastic part. Initial engagement and tightening will cause some stress and should be checked to prevent tensile crazing or breaking. Stress relaxation of plastic threads can lead to loosening of a connection, and possibly part failure.

When designing parts with molded-in threads, consider the following factors.

- Thread Damage: Avoid feather edges on thread runouts to prevent cross threading and thread damage.
- Roots and Crests: Avoid sharp roots and crests on threads to reduce stress concentrations and make filling the mold easier.
- Mold Cost: Internal threads, formed by collapsible or unscrewing cores, and external threads, formed by split cores or unscrewing devices, increase mold cost.

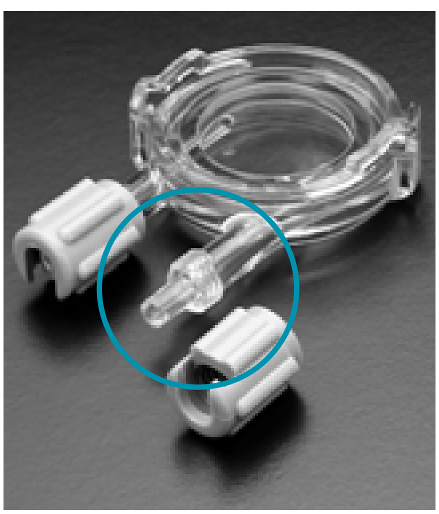
**Figure 3** **Molded-In Threads**



## SELF-THREADING OR SELF-TAPPING SCREWS

Self-threading screws, classified into two categories for plastic parts — thread-cutting or thread-forming, are made in accordance with American National Standard ANSI B18.6.4. Various DIN and ISO specifications cover metric self-threading screws.

Mechanical fasteners give you detachable connections that are both reliable and cost-effective. Driving the proper screw directly into a thermoplastic part results in pullout force levels comparable to those using threaded metal inserts.



Single-use, medical device with molded-in threads for catheter couplings.

**Figure 4**


Thread-cutting screws can be used for Covestro thermoplastic resins.

*Thread-Cutting*

Thread-cutting screws cut away material from the boss inner diameter to form a mating thread. Compared to thread-forming screws, the radial and hoop stresses in the boss wall are lower after installation, resulting in better long-term performance. Typically, thread-cutting screws are classified as ANSI BT (Type 25), ANSI T (Type 23) and the Hi-Lo* screw with a cutting edge on its tip (see figure 4).

In multiple assembly/disassembly operations, thread-cutting screws must be reinstalled carefully to avoid damaging the previously cut threads. Alternatively, replace Type 23 thread-cutting screws with standard machine screws. Because Type 25 and Hi-Lo* screws have non-standard thread pitches, you cannot substitute a standard machine screw for these types.

*Thread-Forming*

Thread-forming screws do not have a cutting tip. They displace material in the plastic boss to create a mating thread. Because this process generates high levels of radial and hoop stress, avoid using these screws with less-compliant materials, such as Makrolon polycarbonate resins or polycarbonate blends. As an alternative, use thread-cutting screws for these materials.

Stress caused during installation of thread-forming screws can be reduced if sufficient frictional heat is generated in the contact area. Use an installation speed of 300 – 500 rpm for most screw sizes.

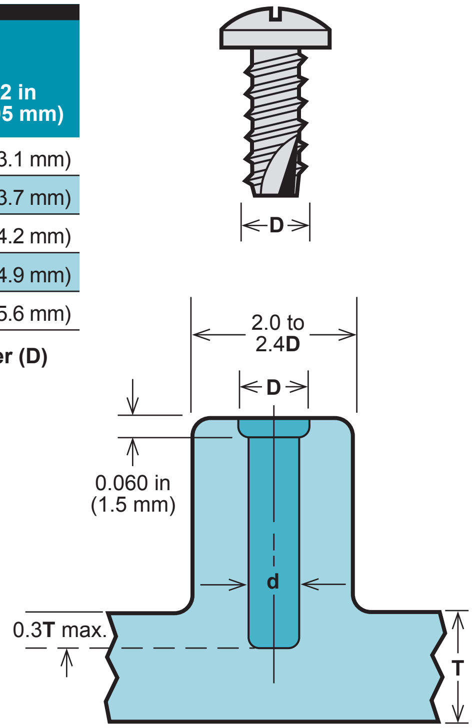
* Hi-Lo is a trademark of Shakeproof Division of Illinois Tool Works Inc.

Figure 5

| Screw Size | Diameter ±0.002 in D(±0.0005 mm) | ±0.002 in d(±0.0005 mm) |
|---|---|---|
| #6 | 0.140 in (3.6 mm) | 0.123 in (3.1 mm) |
| #8 | 0.166 in (4.2 mm) | 0.145 in (3.7 mm) |
| #10 | 0.189 in (4.8 mm) | 0.167 in (4.2 mm) |
| #12 | 0.219 in (5.6 mm) | 0.191 in (4.9 mm) |
| 1/4" | 0.250 in (6.4 mm) | 0.220 in (5.6 mm) |

**Screw Length Minimum: 2.3 x Diameter (D)**

**Suggested Boss Inner Diameter (d): 0.88 x Diameter (D)**




These boss designs for thread-cutting screws are based upon structural considerations. Other design details addressing aesthetic considerations are available.

For more information on self-threading screws and their availability, contact:

*Shakeproof*
Elgin, IL 60120
(847) 741-7900

*Camcar/Textron*
Rockford, IL 61104
(815) 961-5305

*ATF*
Lincolnwood, IL 60645
(847) 677-1300

*Continental/Midland, Inc.*
Park Forest, IL 60466
(847) 747-1200

## *Screw Bosses*

Design screw bosses with care. While small boss diameters reduce the tendency for sinks and/or voids because they have thin side walls, they may not provide sufficient structural strength to withstand assembly hoop stress. See figure 5 for suggested boss design.
A counterbore, provided as a lead-in, helps align the screw and reduces hoop stresses at the top of the boss, where stress-cracking generally starts. Tables 2A through 2D list some average pull-out forces and various torque data for thread-cutting screws tested in selected Covestro resins. For this data, the screws were installed in the manufacturers' suggested hole diameters. The screw boss outer diameter was approximately twice the screw outer diameter.

**Table 2A** **Thread-Cutting Screw Data for Makrolon 3200 Polycarbonate Resin**

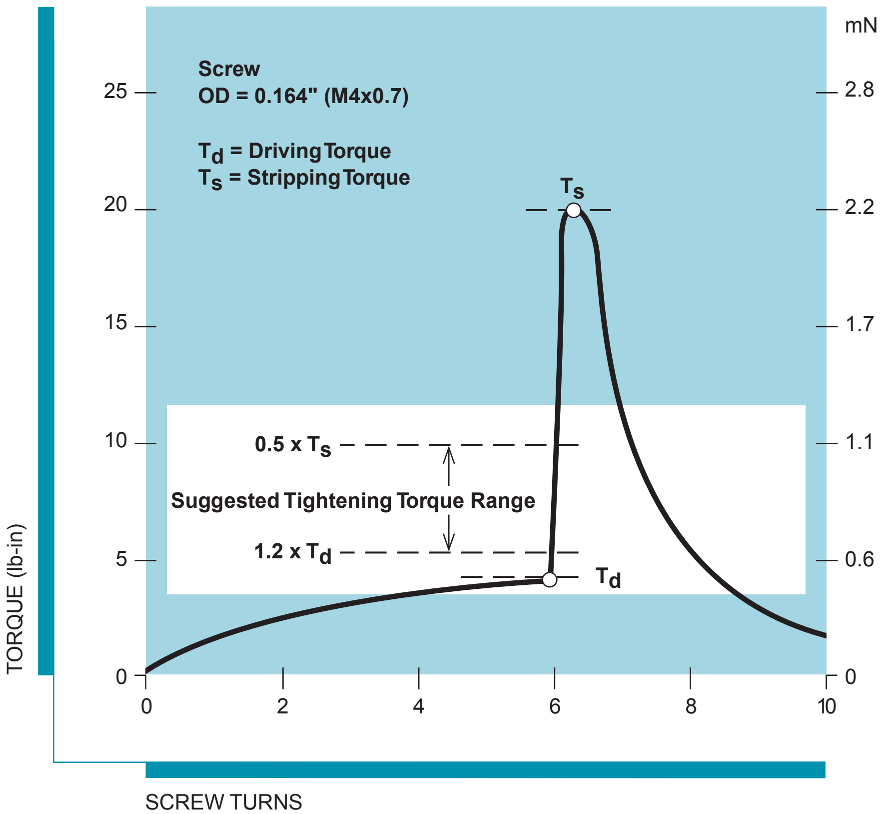
| Screw Size Type | Screw Length in (mm) | Hole Diameter in (mm) | Drive Torque $T_d$ lb-in (N•m) | Recommended Tightening Torque $T_t$ lb-in (N•m) | Stripping Torque $T_s$ lb-in (N•m) | Screw Pullout lb (N) |
|---|---|---|---|---|---|---|
| **#6, Type 23** | 0.375 (9.5) | 0.120 (3.0) | 8 (0.9) | 14 (1.6) | 25 (2.8) | 360 (1600) |
| **#6, Type 25** | 0.500 (12.7) | 0.120 (3.0) | 6 (0.68) | 16 (1.8) | 30 (3.4) | 568 (2528) |
| **#6, Hi-Lo** | 0.750 (19.0) | 0.115 (2.9) | 5 (0.56) | 14 (1.6) | 30 (3.4) | 668 (2973) |
| **#8, Type 23** | 0.500 (12.7) | 0.146 (3.7) | 9 (1.0) | 21 (2.4) | 38 (4.3) | 556 (2474) |
| **#8, Type 25** | 0.562 (14.3) | 0.146 (3.7) | 18 (2.0) | 28 (3.0) | 50 (5.6) | 884 (3934) |

**Table 2B** **Thread-Cutting Screw Data for Bayblend FR-110 PC ABS Resin**

| Screw Size Type | Screw Length in (mm) | Hole Diameter in (mm) | Drive Torque $T_d$ lb-in (N•m) | Recommended Tightening Torque $T_t$ lb-in (N•m) | Stripping Torque $T_s$ lb-in (N•m) | Screw Pullout lb (N) |
|---|---|---|---|---|---|---|
| **#6, Type 23** | 0.375 (9.5) | 0.120 (3.0) | 3.3 (0.37) | 5.6 (0.63) | 10.15 (1.14) | 349 (1552) |
| **#6, Type 25** | 0.500 (12.7) | 0.120 (3.0) | 3.3 (0.37) | 7.9 (0.89) | 17.16 (1.93) | 308 (1370) |
| **#8, Type 23** | 0.500 (12.7) | 0.136 (3.5) | 4.9 (0.55) | 8.4 (0.95) | 15.5 (1.75) | 479 (2130) |
| **#8, Type 25** | 0.562 (14.3) | 0.146 (3.7) | 4.2 (0.47) | 11.5 (1.3) | 26.2 (2.96) | 512 (2277) |

Suggested Tightening Torque

Figure 6



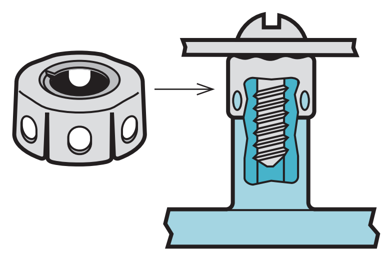

*Self-Piercing/Self-Drilling Screws*

Generally, self-piercing or self-drilling screws that do not need a pilot hole, or screws that are force-fit into a receiving hole should not be used with parts made of Covestro thermoplastics; these produce high hoop stresses.

*Boss Caps*

Boss caps, such as On-sert* caps, may help when higher tightening torques and positive screw alignment are necessary (see figure 7). Carefully select the proper screw type for the plastic material used because the wrong screw may still crack a part even with the use of a boss cap.

Figure 7



On-sert* fasteners fit over plastic bosses providing additional support.

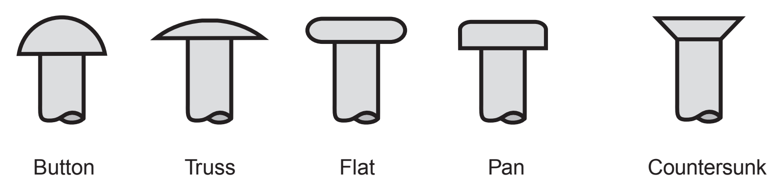
*Tightening Torque*

The torque required to tighten a screw should be at least 1.2 times the driving torque ($T_d$), but should not exceed one-half the maximum, or stripping torque ($T_s$) (see figure 6). Actual test data determines driving and maximum torques.

Use a **thread engagement** of at least 2.3 times the screw diameter for self-threading screws.

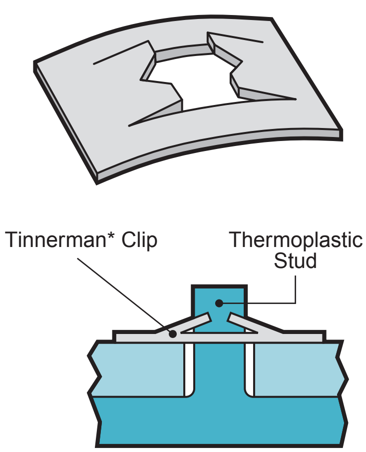
* On-sert is a trademark of the Palnut Company

Figure 8



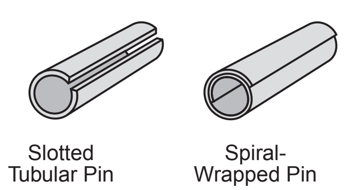

Four standard rivet heads for use with Covestro thermoplastic resins.

Figure 9




Spring steel fasteners.

Figure 10




## THREAD LOCKERS

Generally, thread lockers can be chemically aggressive to plastics. If you are using a thread-locking liquid to secure metal fasteners, fully test the liquid for chemical compatibility with the thermoplastic material before production use. Request a copy of *Chemical Compatibility Test for Unreinforced Thermoplastic Resins* from Covestro for further information.

## RIVETS

Rivets provide a low-cost, simple installation process that can be easily automated. Use them to join thin sections of plastics, plastic to sheet metal or plastics to fabric. To minimize stresses, use rivets with large heads — three times the shank diameter is suggested — and washers under the flared end. Never use countersunk rivets (see figure 8). Calibrate the rivet-setting tools to the correct length to minimize compressive stress and shear in the joint area.

## SPRING-STEEL FASTENERS

Self-locking steel fasteners and push-on spring-steel fasteners, such as Tinnerman* clips (see figure 9), offer another option for assemblies subjected to light loads. Usually pushed over a molded stud, these fasteners are frequently used in applications such as circuit boards. The plastic stud should have a minimum 0.015 inch (0.38 mm) radius at its base.

**Slotted tubular spring pins and spiral-wrapped (roll) pins** (see figure 10) are typically used in shear-loading applications. Pressed into preformed holes with an Arbor press or drill/hammer machine, these pins can cause high hoop stress similar to those in press fits (see page 24). This may result in part crazing or cracking in some plastics.

* Tinnerman is a trademark of the Eaton Corporation

## JOINING DISSIMILAR MATERIALS

In a typical, large plastic and metal assembly where movement is restricted, high compressive or tensile stresses can develop. Figure 10A shows a large plastic part fastened to a metal base or bracket. As the ambient temperature rises, the plastic will expand more than the metal because the plastic has a higher coefficient of linear thermal expansion. In this example, the plastic's expansion coefficient is four to six times higher.

Because the plastic part expands more, it develops a strain-induced compressive stress. An equal tensile stress develops in the metal part. In most cases, these stresses are more harmful for the plastic part than the metal part. An approximation for thermally induced stress in the plastic is:

$$\sigma_T = (\alpha_m - \alpha_p) \cdot E_p \cdot \Delta T$$

Where:

$\alpha_m$ = Coefficient of linear thermal expansion of the metal

$\alpha_p$ = Coefficient of linear thermal expansion of the plastic resin

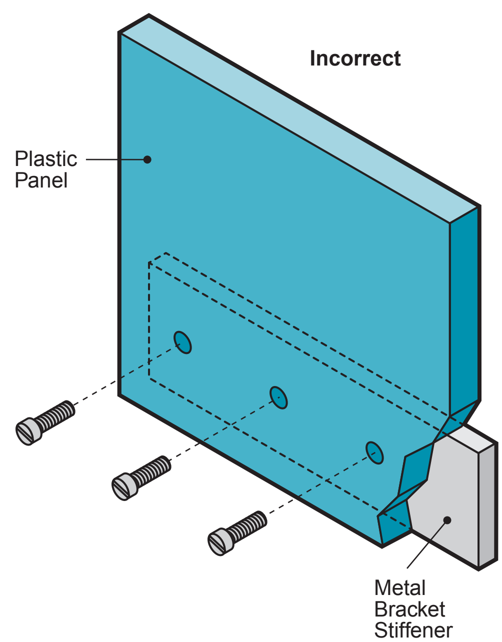
$E_p$ = Young's modulus of elasticity for the plastic resin

$\Delta T$ = Change in temperature

(When performing these calculations, a consistent system of units is essential. Use the temperature units specified in "α.")

Typically, as the temperature rises, the stiffness of the plastic part decreases. With even higher temperatures, the plastic part will eventually buckle. The opposite occurs when the temperature decreases: The plastic part shrinks, developing strain-induced tensile stress. With much lower temperatures, stiffness increases even more and the strain-induced stress approaches critical levels, leading to part failure.

Figure 10A

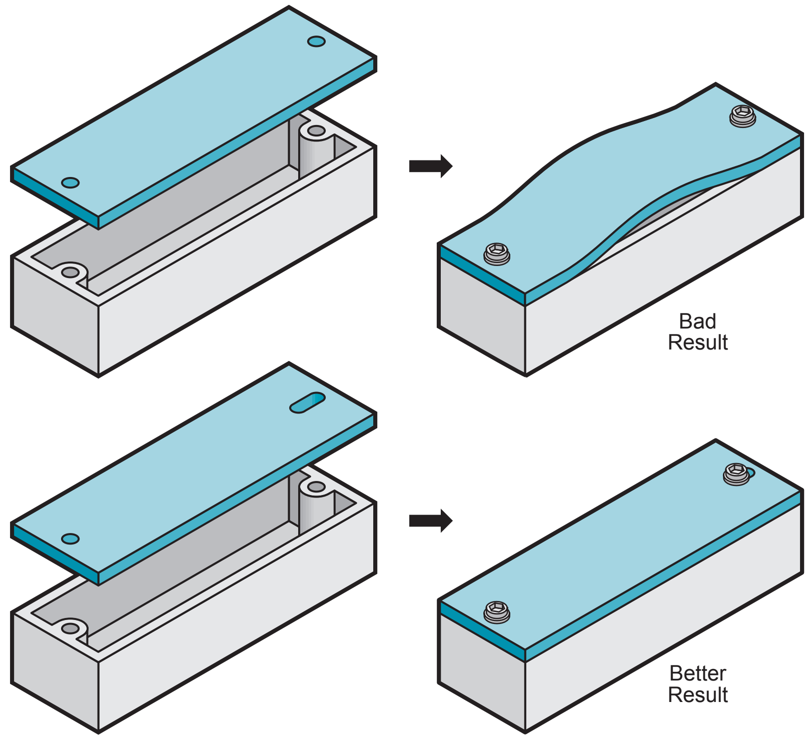



Restricted fabrication technique is not recommended.

To avoid these problems, use slotted screw holes in the plastic part for temperature-sensitive designs, such as a large automotive cowl vent panel. Figures 10B through 10D illustrate this concept. As shown in these figures, the slotted holes allow differential thermal expansion and contraction of the assembly's plastic and metal parts.

When joining plastic and metal parts, tightening torque for the inserted screw has important implications. Do not tighten fasteners to the point where joint friction and compressive loads prevent relative movement. If the fasteners are too tight, the effect of the slotted holes will be negated, leading to possible part failure.

**Figure 10B**




The slotted hole and sliding attachment at one end of the plastic cover in the lower assembly enables it to accommodate the thermal expansion difference with the metal base.

Other factors to consider when joining plastic and metal parts include:

- The span between mounting points;
- The magnitude of the temperature range; and
- The relative thermal expansion coefficients of the materials used in the assembly.

Consult the Covestro data sheet for the specific grade you're using if it does not appear in table 3.

**Table 3** **Coefficient of Linear Thermal Expansion (CLTE) Values for Common Materials**

| Material | CLTE ($10^{-5}$ • in/in/°F) | CLTE ($10^{-5}$ • mm/mm/°C) |
|---|---|---|
| **Bayblend T-85** | 4.0 | 7.2 |
| **Bayblend T-65** | 4.3 | 7.7 |
| **Bayblend T-45** | 4.6 | 8.3 |
| **Makrolon (Most)** | 3.9 | 7.0 |
| **Aluminum** | 1.3 | 2.3 |
| **Brass** | 0.95 | 1.7 |
| **Magnesium Alloys** | 1.5 | 2.2 |
| **Steel** | 0.80 | 1.4 |
| **Wood (W/Grain)** | 0.36 | 0.65 |
| **Wood (Acc/Grain)** | 2.9 | 5.2 |
| **Zinc Alloys** | 1.5 | 2.7 |
| **Glass** | 0.5 | 0.9 |

*Worked Example*

(Note: Bayblend T-85 resin is used as an example. Please substitute values for your Covestro material for proper results.)

Assume that an assembly is made of Bayblend T-85 resin and an attached aluminum stiffener, and will be exposed to a temperature range of -20 to 120°F. The outboard assembly fasteners are 48 inches apart and the part was assembled in an ambient temperature of 70°F. To determine the change in length start with the basic formula:

$$\Delta L = \alpha \cdot L \cdot \Delta T$$

Then substitute the difference of coefficients for $\alpha$ in the formula:

$\alpha$ for Aluminum is 1.3 x $10^{-5}$ in/in/°F

$\alpha$ for Bayblend T-85 is 4.0 x $10^{-5}$ in/in/°F

$\Delta L = (\alpha_{plastic} - \alpha_{metal}) \cdot \Delta T \cdot L$

$\Delta L = (4.0 \times 10^{-5} - 1.3 \times 10^{-5}) \times (120 - (-20)) \times 48$

$\Delta L = 0.181$ inch

The total difference in thermal expansion is 0.276 inch. Because we have two assembly points, the movement between fasteners is 0.276/2 or 0.138 inch. In this example, you would have to plan for a range of movement of 0.138 inch at each fastening site. You must allow for this expansion in your design to prevent stresses that could jeopardize the assembly, which can be estimated using the following formula:

$$\sigma = (\alpha_p - \alpha_m) \cdot E_p \cdot \Delta T$$

Where:

$\alpha_m$ = Coefficient of linear thermal expansion of the metal

$\alpha_p$ = Coefficient of linear thermal expansion of the plastic resin

$E_p$ = Young's modulus of elasticity for the plastic resin

$\Delta T$ = Change in temperature

(When performing these calculations, a consistent system of units is essential. Use the temperature units specified in "α.")

**Figure 10C** **Joining Dissimilar Materials**

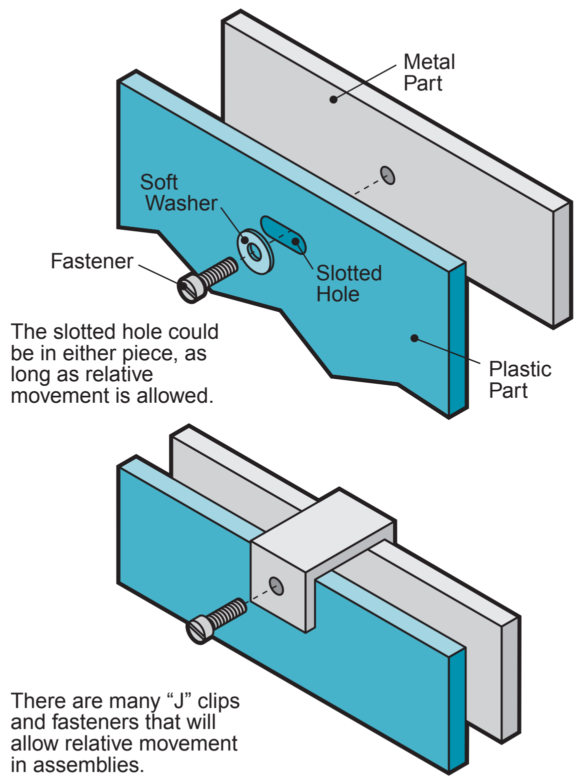
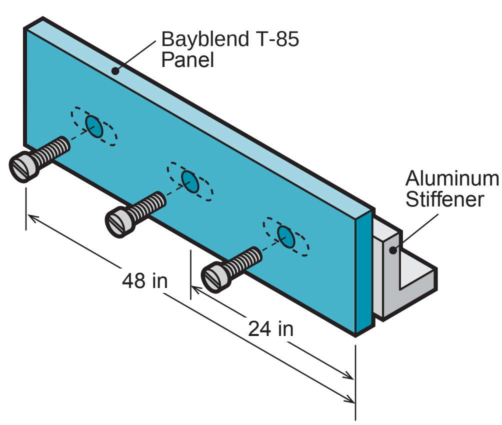



**Figure 10D**




Allow for relative movement in assemblies of dissimilar materials.

*Ultrasonic assembly, one of the most widely used joining techniques for thermoplastics, makes permanent, aesthetically pleasing joints. Four common ultrasonic assembly techniques — welding, staking, spot welding, ultrasonic inserts — use high-frequency mechanical vibration to melt mating surfaces. This section discusses various ultrasonic assembling techniques.*

*An ultrasonic plastic assembly system converts standard electrical energy from 50/60 Hz to 20 to 40 kHz and then into mechanical vibratory energy. A 40-kHz machine produces an amplitude of one-half that of a 20-kHz unit, allowing for a more gentle action.*

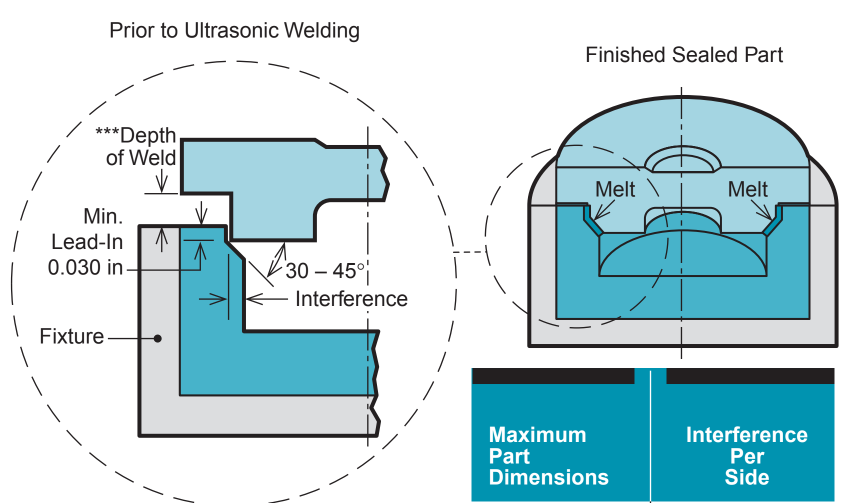
## ULTRASONIC WELDING

Ultrasonic welding is an excellent bonding method for thermoplastics. Generally, small amounts of fillers, such as fiberglass, will not inhibit welding. If glass content in the resin exceeds 10%, some horn wear on the welding device may occur. If glass content exceeds 30%, the bond may be poor. Additionally, some external mold-release agents, lubricants and flame retardants may affect weld quality adversely.

The most important design feature in an ultrasonically welded joint, the triangular-shaped energy director, minimizes initial contact between the parts. During welding, the energy director tip melts rapidly, filling the joint with molten resin and melting the surrounding areas slightly. The melted material from both parts solidifies to create a permanent bond.

Design energy directors with an apex angle from 60 to 90° (see figure 14). For thin-walled parts, a 60° energy director may be more practical. Generally, the base width of the energy director should not be more than 20 to 25% of the wall thickness supporting it. Figures 13 through 15 show a variety of joint designs using energy directors. (An energy director with a 90° apex angle creates more melt and will improve joint strength marginally for some semi-crystalline resins, such as Makroblend and Polyamides)

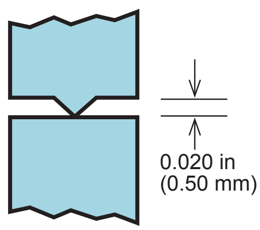
**Figure 11** **Shear Joint**




| Maximum Part Dimensions | Interference Per Side |
|---|---|
| **0.75 in or less** | 0.008 – 0.012 in |
| **0.75 – 0.150 in** | 0.012 – 0.016 in |
| **1.50 in or larger** | 0.016 – 0.020 in |

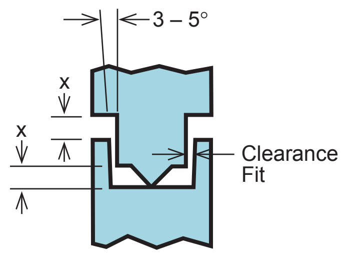
***Minimum Depth of Weld: 1.1 x Wall Thickness

**Figure 12**




Butt joint with energy director.

**Figure 13**

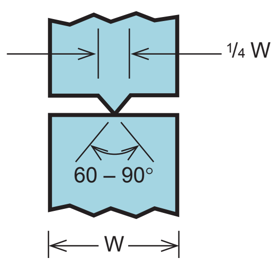



Tongue and groove joint.

For optimum welding:

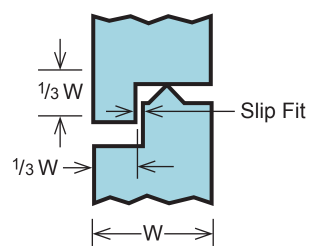
- The horn, fixture and parts must be aligned properly;
- The stationary part should fit snugly in the nest or fixture;
- The height of the energy director should be approximately 0.020 inch (0.51 mm); and

**Figure 14**




Apex angle 60 – 90°.

**Figure 15**




Step joint.

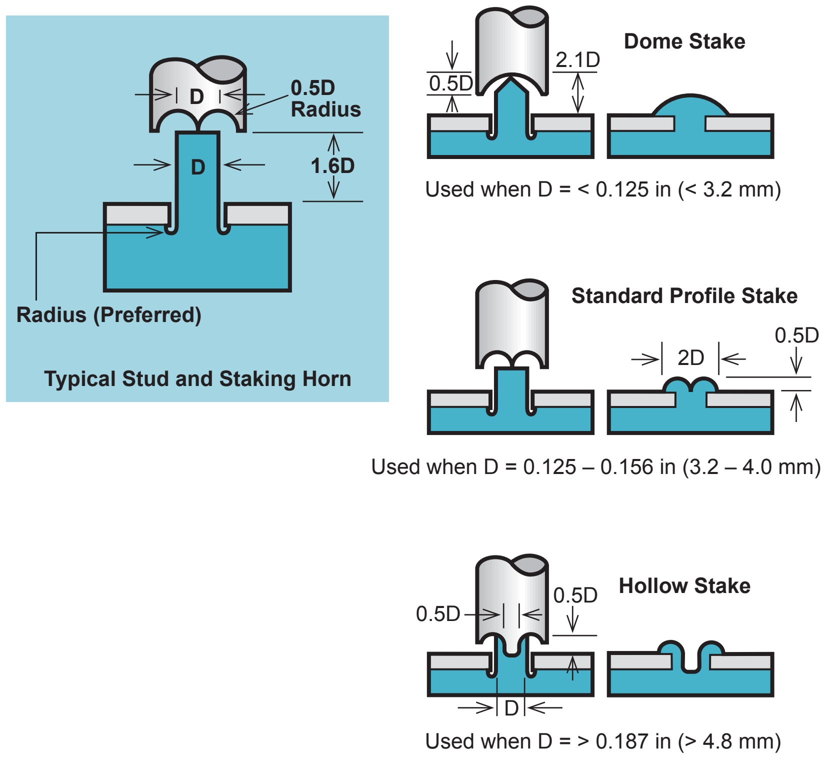
For optimum ultrasonic welds, join parts made of the same resin. Parts molded from dissimilar resins can be welded ultrasonically if they share a common polymer component, such as PC welded to PC/ABS. Additionally, testing at Covestro shows some grades of Makrolon polycarbonate resins can be welded to select grades of ABS resin.

In applications requiring a water-tight or hermetic seal, a shear-joint design usually performs better than an energy director design (see figure 11). Shear joints require more energy to weld than energy director joints. Do not exceed the machine energy limits because of part size.

## ULTRASONIC STAKING

In ultrasonic staking, high-frequency vibrations from a specially contoured horn melt the top of a thermoplastic stud which protrudes through a hole in the mating part of the assembly (see figure 16). Mating material can be a dissimilar plastic or even metal. When the top of the stud melts, it forms a head that locks the two components together. The base of the stud must be rounded to help reduce stress concentration. Additionally, the through hole on the mating part should be a close fit to prevent melt from flowing into the gap between the stud and the mating part.

Figure 16




Ultrasonic staking designs for Covestro thermoplastics.

## ULTRASONIC INSERTS/ HEAT INSERTS

For installing inserts, both of the preferred bonding techniques — ultrasonic energy and heat — provide a solid bond without the high stresses found in press fits and expansion inserts. As shown in figure 18, the boss OD should be 2 to 2.5 times the insert diameter for optimum insert performance. The receiving hole can be either straight or with an 8° taper depending upon the type of insert used. As a general rule, the receiving hole diameter can be approximately 0.015 to 0.020 inch (0.38 to 0.51 mm) smaller than the insert OD. For your specific application, use the insert manufacturer's recommendation for the receiving hole size for the particular insert that will be used. Also, the receiving hole should be deeper than the insert length to prevent the insert from bottoming out and to provide a well for excess plastic melt.

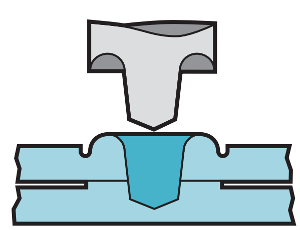
## ULTRASONIC SPOT WELDING

Requiring no preformed holes or energy directors, ultrasonic spot welding joins two layers of thermoplastic resins with similar melting temperatures in a single location, forming a permanent bond.

In ultrasonic spot welding, the pilot tip melts through the first surface. As the tip penetrates the second or bottom surface, displaced molten plastic flows between the two surfaces, forming a bond (see figure 17).

Generally used for large parts or sheets, ultrasonic spot welding can be done with a portable, hand-held device and power supply.

Figure 17

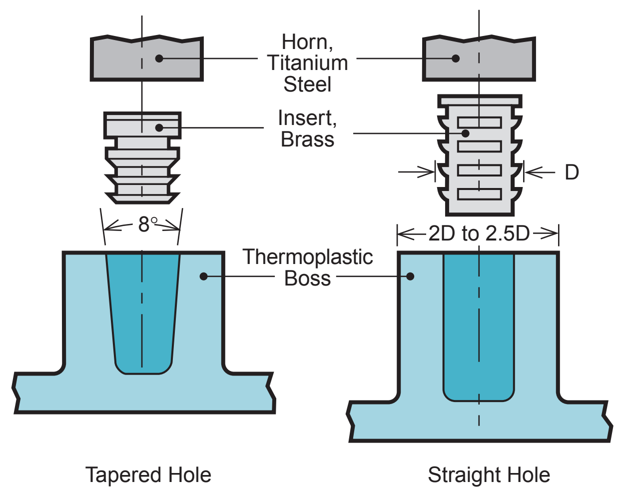


Ultrasonic spot welding.

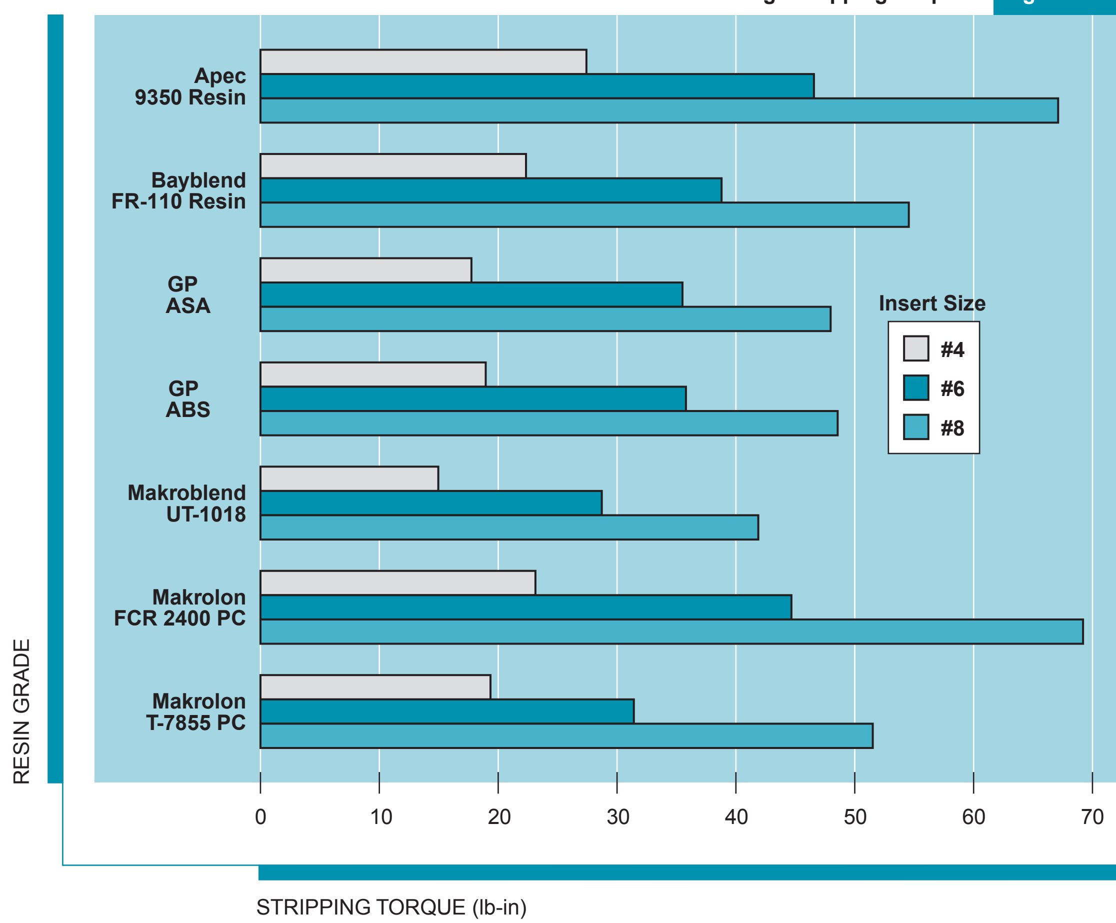
When installed, the insert's top should be flush with or slightly above the boss's top surface, but no more than 0.010 inch (0.003 mm). If the insert is below the top surface, the embedded insert could pull out of the parent material as the screw is tightened, a condition sometimes referred to as "jackout."

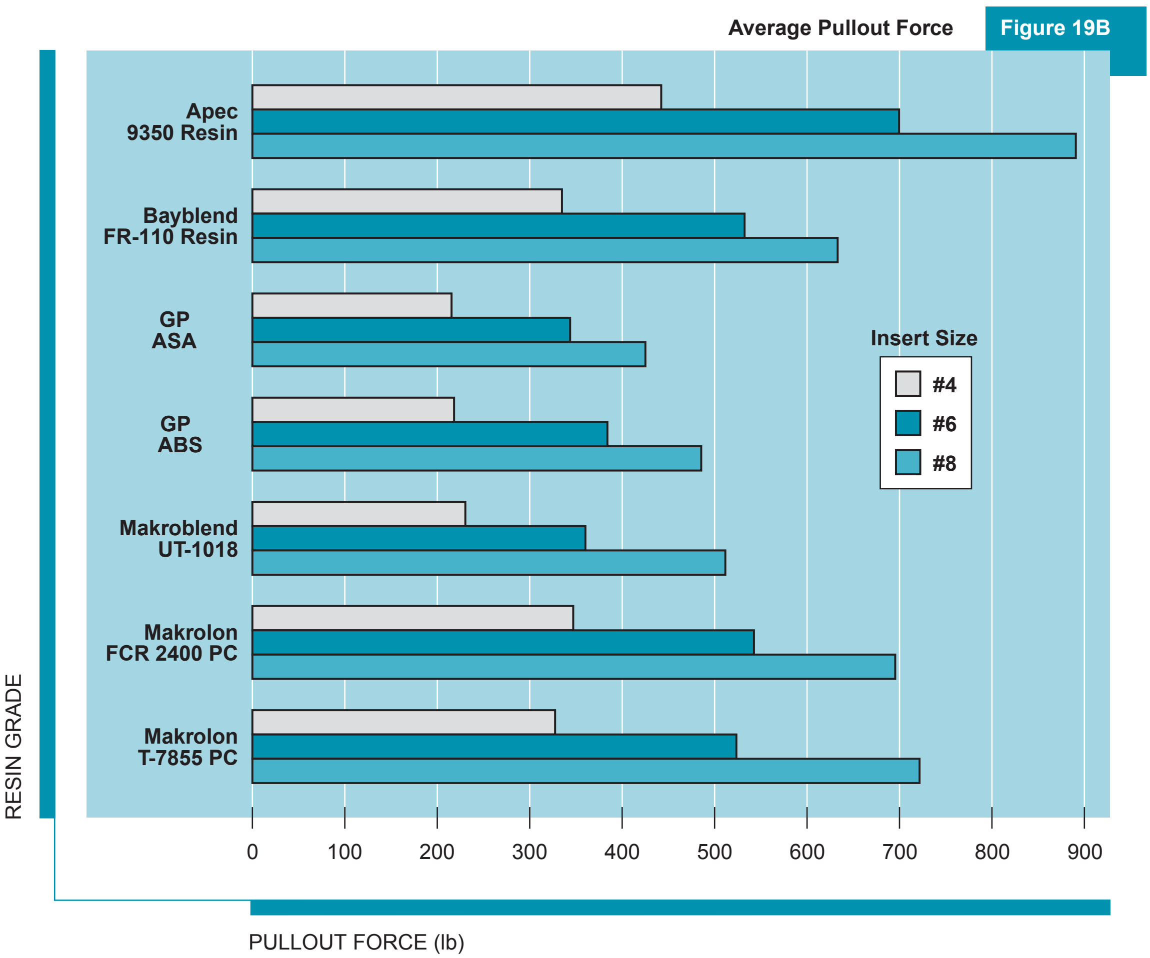
Figures 19A and 19B show pullout strength and stripping torque values for a variety of ultrasonic inserts tested at Covestro. These values represent an average for *various insert types* and should be used only for general guidance.

**Ultrasonic Inserts** **Figure 18**




**Average Stripping Torque** **Figure 19A**






Inserts were supplied by:

Dodge Ultrasert II®
*HeliCoil Products*
Shelton, CT 06484
(203) 743-7651

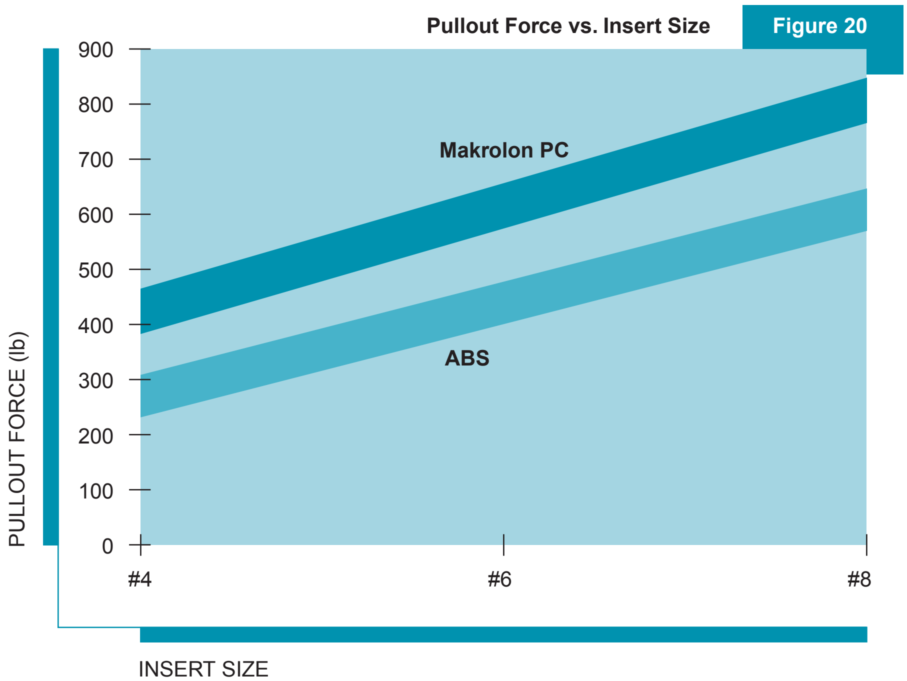
P.S.M. Sonic-Lok 86 Series
*P.S.M. Fastener Corporation*
Fairfield, NJ 07004
(201) 882-7887

Spirol® Heat/Ultrasonic Insert
*Spirol International Corporation*
Danielson, CT 06239
(860) 774-8571

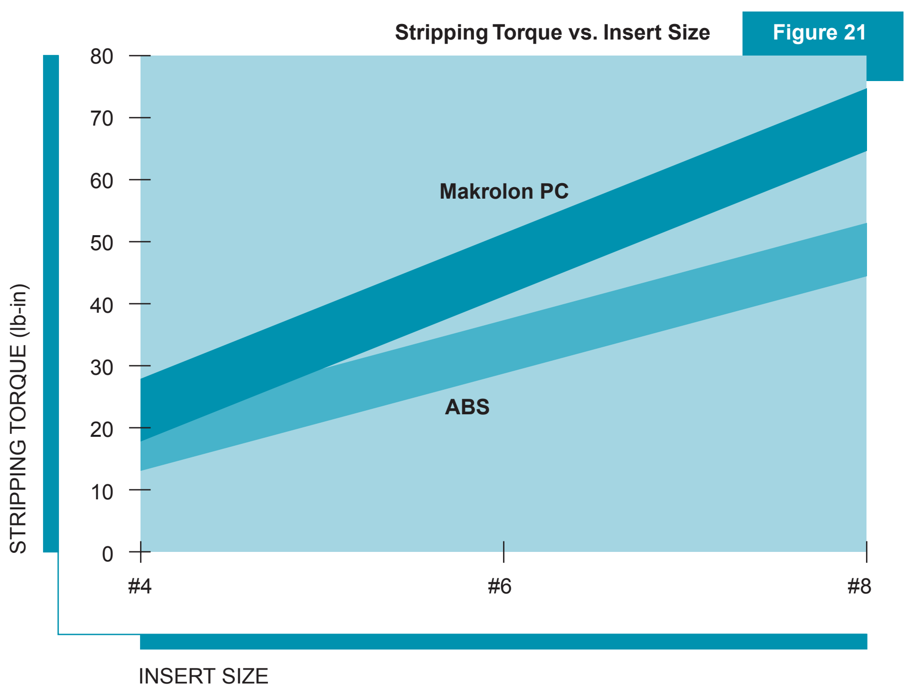
Yardley Type H Intro Sert®
*Yardley Products Corporation*
Yardley, PA 19067
(215) 493-2723

Barb-Sert® Insert
*Groove Pin Corporation*
Ridgefield, NJ 07657
(201) 945-6780

An alternate way to install inserts instead of using ultrasonic energy is heat insertion. In this method, inserts are heated to a pre-determined temperature, derived empirically for each insert and part. Much like ultrasonic inserts, heat inserts are positioned via air pressure. The plastic around the insert melts, causing a bond. Use the same basic guidelines for boss design and installation as for inserts that are ultrasonically installed. Figures 20 and 21 show pullout strength and stripping torque values for heat inserts.




Pull-out strength of heat inserts in Makrolon 3200 PC and an ABS resin.




Stripping torque of heat inserts in Makrolon 3200 PC and an ABS resin.

**For more information on ultrasonic joining techniques, contact:**

*Branson Ultrasonics Corporation*
41 Eagle Road
Danbury, CT 06813-1961
(203) 796-0400

*Dukane Corporation*
2900 Dukane Drive
St. Charles, IL 60174
(630) 584-2300

*Forward Technology Industries, Inc.*
13500 County Road 6
Minneapolis, MN 55441
(612) 559-1785

*Herrmann Ultrasonics, Inc.*
620 Estes Avenue
Schaumburg, IL 60193
(847) 985-7344

*UltraSonic Seal Co.*
368 Turner Industrial Way
Aston, PA 19014
(610) 497-5150

# METAL INSERTS

*If your part is going to be disassembled regularly, consider using metal inserts for joining. Most inserts should be installed ultrasonically or with heat to minimize residual stresses (see page 18). Use and installation suggestions for other types of metal inserts appear in this section.*

## MOLDED-IN METAL INSERTS

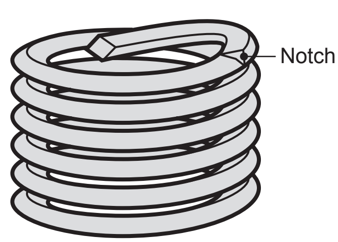
Molded-in metal inserts can cause high residual stresses in plastic bosses. Avoid inserts in parts made of polycarbonate resins and blends, because the residual stress may result in crazing, cracking and eventual part failure. Plastic, having much higher coefficients of thermal expansion than metal, shrinks around the insert and becomes stressed at the interface because the insert imposes a restriction. Because glass-reinforced resins have thermal expansion coefficients closer to those of metals, problems with metal inserts occur less frequently in these resins. Molded-in metal inserts have also been used successfully in some nylons, various grades of thermoplastic urethanes, and styrenic polymers, such as ABS and ASA resins. Always thoroughly test all molded-in inserts in end-use conditions prior to beginning full production runs.

Before inserts are placed in a mold, they should be cleaned to remove foreign matter, including any oils or lubricants. Inserts should seat securely in the mold to prevent floating and possible damage to the mold.

Avoid inserts with sharp knurls or protrusions. Although they can have high pullout values, the sharp points cause a notch effect in plastics which can lead to early failure.

Inserts larger than 0.25-inch (6.35-mm) diameter may induce excessive thermal stresses, which can be partially reduced by preheating the insert prior to placing it in the mold. Preheat inserts used in polycarbonate parts to 350°F to 400°F (177°C to 204°C).

Figure 22




Coiled threaded inserts.

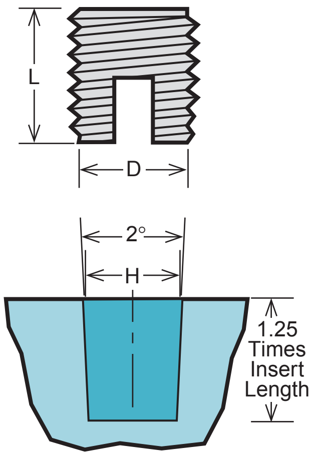
## COIL-THREADED INSERTS

Made into a coil of wire, coil-threaded inserts provide greater wear resistance and strength than the parent material (see figure 22). However, they can also produce high stress in the boss or receiving hole, which may lead to boss failure.

## THREAD-CUTTING INSERTS

With external cutting edges similar to a tap, thread-cutting inserts (see figure 23) cut a clean, even thread when inserted into a molded or drilled hole. These inserts are usually installed with a tap wrench or a drill press and tapping head. Never use lubricants or cutting fluids when tapping holes in plastic.

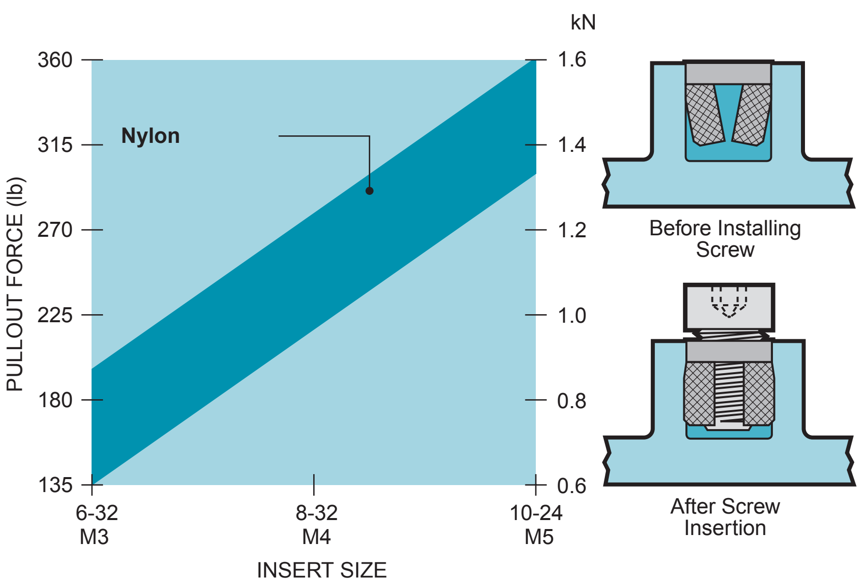
Figure 23




| Inch Sizes<br>Internal Thread Size | Metric Sizes<br>Internal Thread Size | Diameter<br>D (in) | Length<br>L (in) | Recommended Hole Size<br>H (in) |
|---|---|---|---|---|
| **4-40** | M3x0.5 | 0.171 | 0.234 | 0.152 – 0.149 |
| **6-32** | M3.5x0.6 | 0.218 | 0.281 | 0.194 – 0.190 |
| **8-32** | M4x0.7 | 0.250 | 0.328 | 0.226 – 0.222 |
| **10-32** | M5x0.8 | 0.296 | 0.375 | 0.264 – 0.259 |

Tap-Lok® C-Series self tapping insert. Courtesy of Groov-Pin Corporation, Ridgefield, NJ 07657, (201) 945-6780

Figure 24



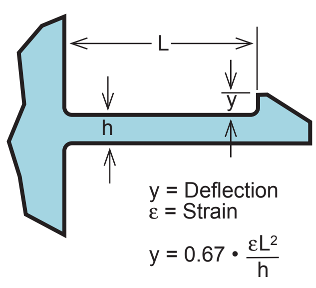

Pullout force for Dodge expansion inserts.

## EXPANSION INSERTS

Installed into slip-fit, molded or drilled holes, expansion inserts have significantly reduced mechanical performance compared to those installed with ultrasonic energy or heat. When a screw is installed, the insert expands against the walls of the hole, which can result in excessive hoop stress that can lead to boss or part failure in polycarbonate materials. Expansion inserts have been used successfully with more compliant resins such as Polyamides and ABS. See figure 24 for typical pullout values for expansion inserts in nylon.

# SNAP AND PRESS FITS

Figure 25




Simple cantilever snap arm.

*Designed into the geometry of mating parts, snap fits offer a very inexpensive, quick and efficient joining method. Press fits must be designed with great care to avoid excessive hoop stress in the assembly. This section discusses snap and press fits, giving common design parameters for their use.*

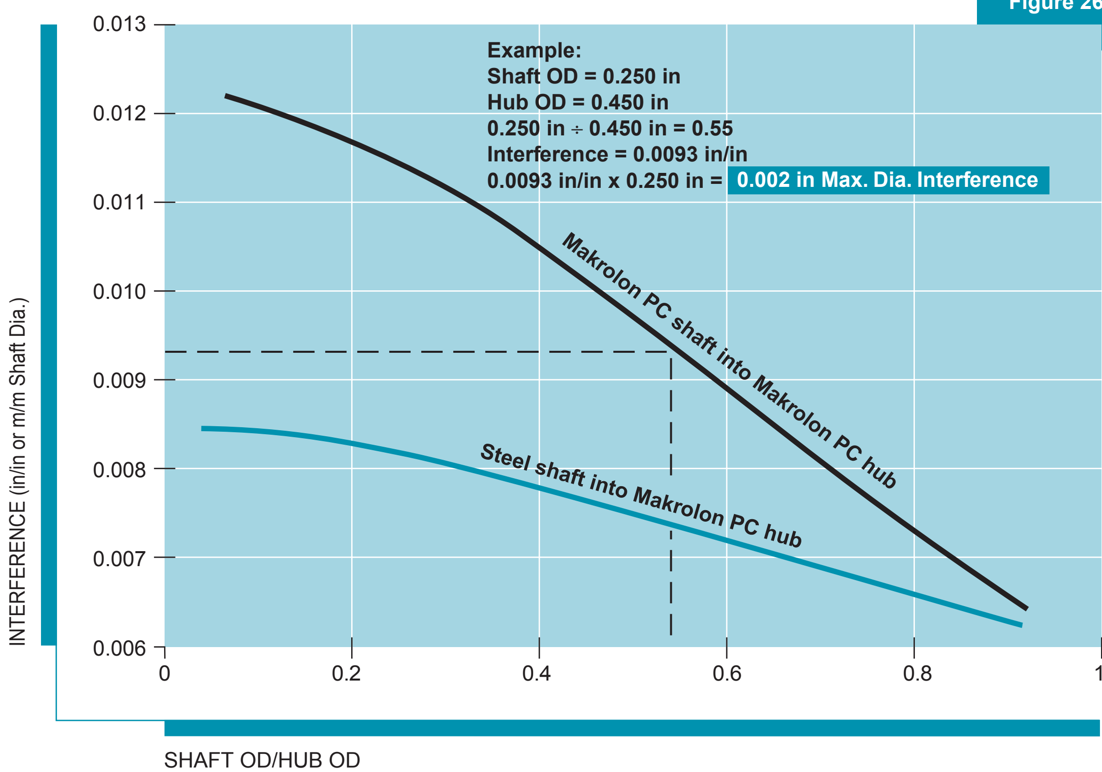
## SNAP FITS

Used commonly to join plastic parts, snap fits offer a simple, economical and efficient joining method. Using snap fits may enhance your part's recyclability because they may reduce or eliminate metal fasteners and allow for easy disassembly (see figure 25 for an example of a cantilever-arm snap fit).

Although the suitability of any given resin varies with part design and use, most plastics can be used for snap fits, particularly if the design calls for a one-time assembly. If the end use calls for repeated assembly and disassembly, reduce the maximum strain to which the part is exposed.

For a comprehensive discussion of and complete design guide for snap fits, please contact your sales representative for a copy of Covestro's *Snap-Fit Joints in Plastics* brochure.

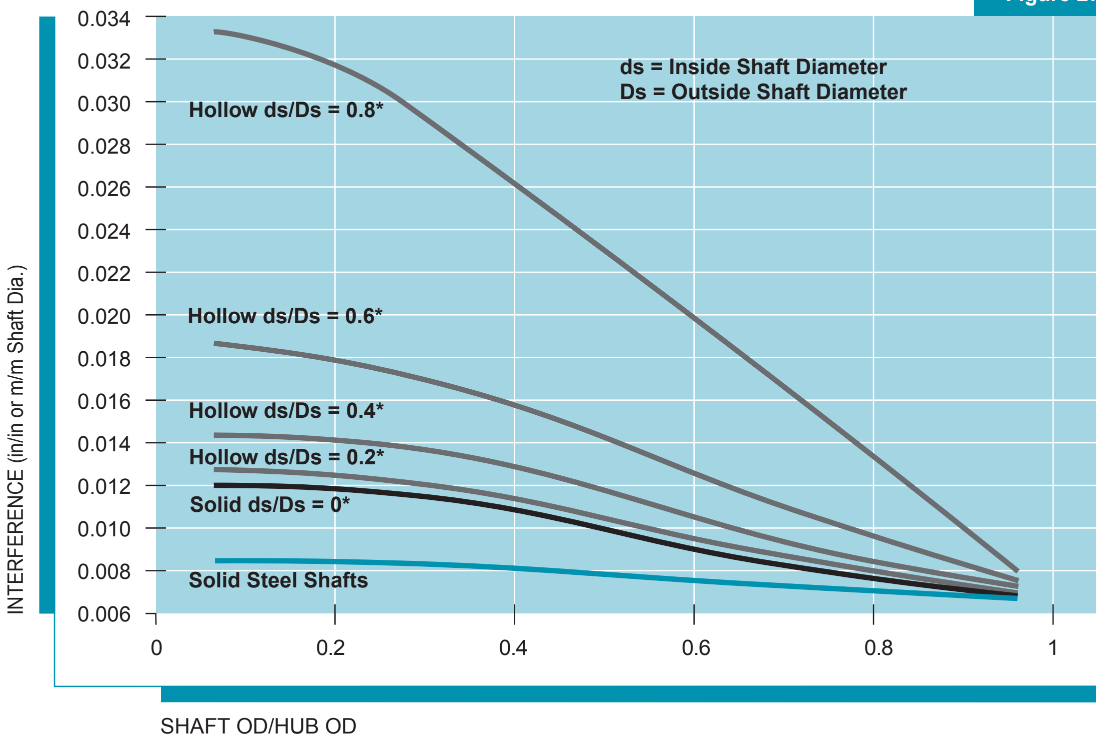
Figure 26




Maximum diametrical interference for Makrolon polycarbonate and steel press fits (solid shafts).

**Figure 27**

Maximum diametrical interference for Makrolon polycarbonate press fits (hollow shafts).




**These curves are for shafts made of Makrolon polycarbonate.*

## PRESS FITS

Because press fits can result in high stresses, use caution when choosing this assembly method. Generally, do not use press fits as a primary joining method for parts made of Covestro resins. Figures 26 and 27 show the maximum diametrical interference recommended for hubs made of Makrolon resin when pressed onto either shafts of Makrolon polycarbonate resin or steel.

The example shown in figure 26 permits only 0.002-inch diametrical interference on the 0.250-inch shaft. Actual production tolerances of the shaft and hub may vary enough to cause a slip fit — such that the part will not function as designed — or excessive interference, leading to high hoop stresses in the plastic hub. For these reasons, press fits are used only rarely in Markolon polycarbonate resin. Other resins, such as ABS, nylon and TPU, can better tolerate excessive interference; but may exhibit stress relaxation, leading to a looser fit over time. We suggest prototyping and thorough testing of all press-fit assemblies.

When using press fits:

- Clean all parts to ensure that they are free of any foreign substance, such as lubricants or degreasers;
- Avoid press fits when the mating parts are made of two different materials and the part will be subjected to thermal cycling; and
- Avoid press fits if the assembly will be subjected to harsh environments during manufacturing, assembly, transportation or end use.

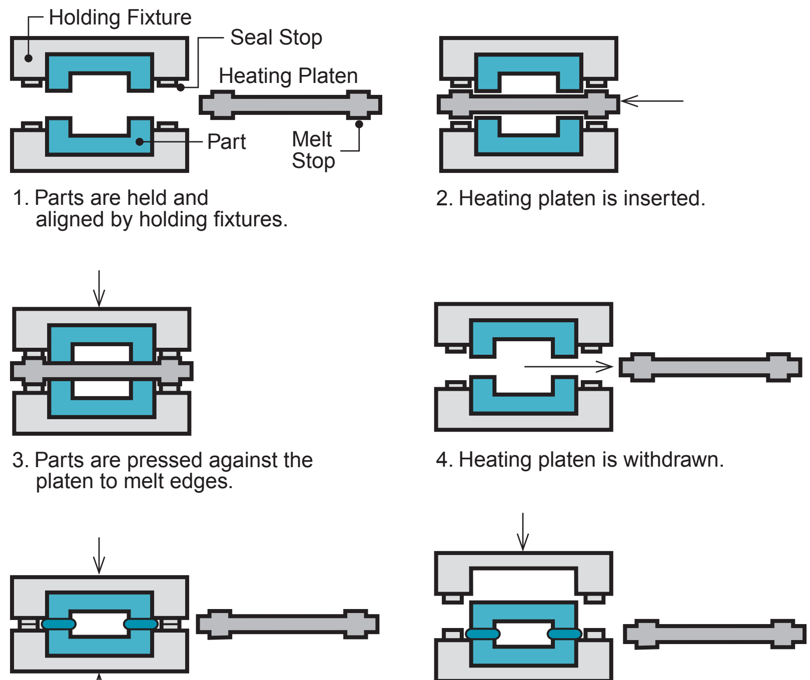
*For permanent, inexpensive joints, consider heat welding and sealing. Although some residual plastic — called "flash" — may detract from the part's appearance, heat welding can be used on parts where aesthetics are not important. As with all bonded joints, increased fillers and fibers may reduce bond strength.*

**Table 4** **Drying Times for Parts to be Joined by Heat Welding and Sealing for Polycarbonate at 250°F (120°C)**

| Polycarbonate Part Thickness, in (mm) | Time (Approx.) |
|---|---|
| 0.020 (0.5) | 20 min |
| 0.031 (0.8) | 30 min |
| 0.040 (1.0) | 40 min |
| 0.062 (1.6) | 2 hr |
| 0.080 (2.0) | 3.5 hr |
| 0.093 (2.4) | 4 hr |
| 0.125 (3.2) | 6 hr |
| 0.187 (4.7) | 14 hr |

*For maximum bonding strength, dry both components before bonding. For example, if you are heat welding Makrolon polycarbonate parts, pre-dry parts at 250°F (120°C) for maximum bond strengths. Drying time and temperature depend upon part thickness and material selected. (see table 4). Be sure that items made of polyamide 6 are kept dry. See handling and storage suggestions under ultrasonic welding.*

**Figure 28** **Hot Plate Welding**




1. Parts are held and aligned by holding fixtures.
2. Heating platen is inserted.
3. Parts are pressed against the platen to melt edges.
4. Heating platen is withdrawn.
5. Parts are compressed so edges fuse together as the plastic cools.
6. Holding fixtures are opened, leaving the bonded part in the lower fixture.

Courtesy of Forward Technology Industries, Inc.,
13500 County Road 6, Minneapolis, MN 55441, Telephone: (612) 559-1785

*To ensure operator's safety, follow the manufacturer's instructions regarding operation of their equipment.*

## HEAT OR HOT-PLATE WELDING

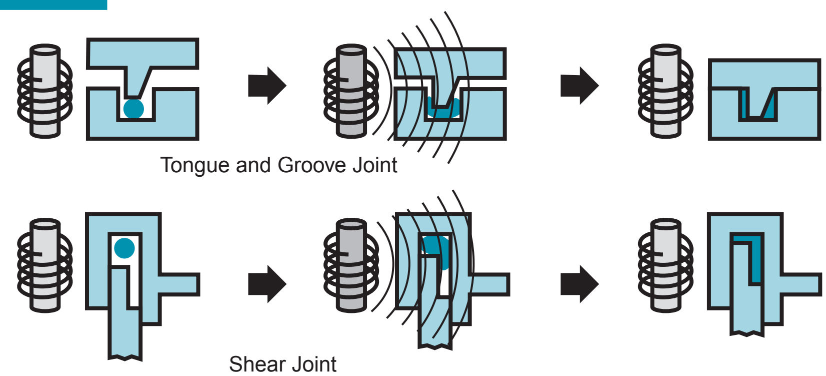
In heat welding, a heated platen, usually coated with polytetrafluoroethylene (PTFE), contacts two plastic parts until the joint area melts. The parts are then pressed together under slight pressure until the bond is set (see figure 28).

## BAR SEALING

A common and practical joining technique, bar sealing involves holding film between a double-heater element for a short period of time at a given temperature and pressure, depending upon resin type and film thickness. Makrolon polycarbonate films up to 0.010 inch (0.25 mm) thick can be bar sealed. Do not seal thicker sheets in this manner, because bond dimensions may distort.

For bar sealing polycarbonate film, the surface temperature of the heater elements should be between 450 and 500°F (230 and 260°C). Typically, you will need a contact pressure of approximately 100 psi (690 kPA) which usually results in a cycle time of 0.5 to 2 seconds, depending upon the thickness of the film to be sealed. Polyamide 6 films also have excellent bar-sealing characteristics.

Figure 29




Electromagnetic or induction welding.

## HOT-KNIFE SEALING

For plastic films that are too thick for conventional bar sealing, hot-knife sealing offers an alternative joining method. In hot-knife sealing, a heated "blade" passes between the parts and applies heat from the seal side. Knife temperature and speed depend upon the resin type and thickness. After adequate heating, surfaces are pressed together and held at a specified contact pressure until the bond solidifies. If you apply excessive pressure during curing, the plastic film may develop a localized strain. Additionally, as sheet thickness increases, its stiffness may prevent the successful use of this bonding method.

For polycarbonate sheet sealing, the surface temperature of the blade should be about 550 to 650°F (290 to 345°C). You need to regulate the speed of the heated element so that the surfaces to be joined reach a temperature of about 450°F (230°C). Then, they are immediately pressed together at a contact pressure of about 100 psi (690 kPa) and held together for a few seconds until the bond solidifies.

## ELECTROMAGNETIC OR INDUCTION WELDING

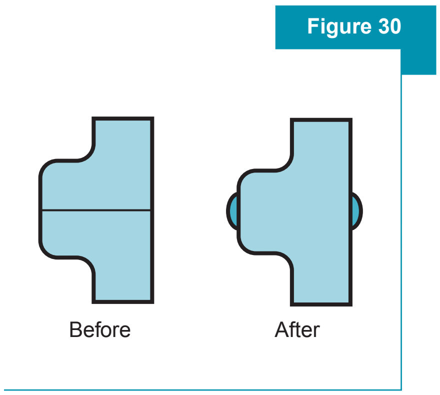
Using the principles of inductive heating to create fusion temperatures in a joint area, electromagnetic welding creates excellent hermetic or high-pressure seals. This process requires bonding material, usually supplied as extruded profiles such as strands (beads), tape or sheet, or special injection-molded profiles conforming to a particular joint contour.

In this welding process, ferromagnetic particles are mixed with a thermoplastic matrix to form a magnetically active material for bonding. Bonding material is placed at the interface of the two plastic parts, which are then briefly exposed to an oscillating electromagnetic field. A high-frequency alternating current (5 to 7 MHz) flows through a set of conductive work coils to create the electromagnetic field. Within seconds, the parts reach fusion temperature, melting the binder and interface (see figure 29).

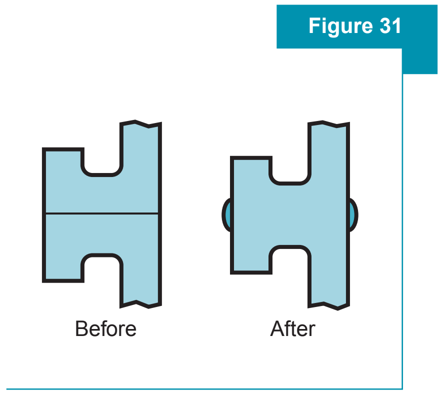
Fusion times range from a fraction of a second for small assemblies to 30 seconds for large assemblies — those with bond lines of as much as 20 feet. For further information on this welding technique, contact:

*Emabond Systems*
Specialty Polymers & Adhesives Division
*Ashland Chemical Company*
49 Walnut Street
Norwood, NJ 07648
(201) 767-7400

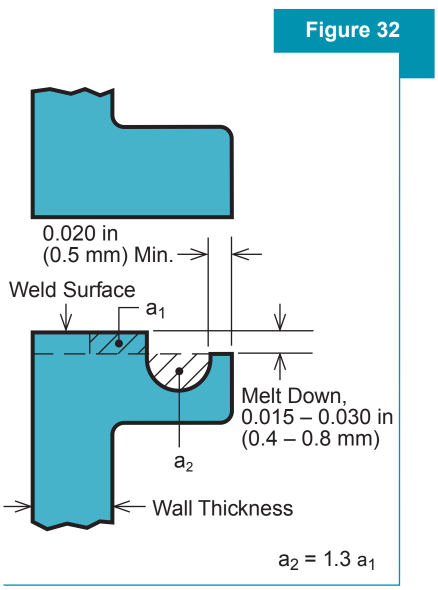
*Hellerbond*
P.O. Box 20156
Columbus, OH 43220
(614) 527-0627



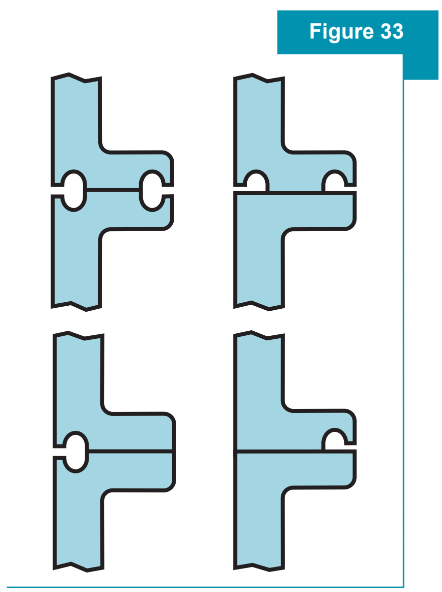

Butt joint.




Flanged joint, for thin or long, unsupported walls.




Butt joint with flash trap.




Variations with flash traps.

## VIBRATION WELDING

A friction-welding technique, vibration welding uses a machine that operates at a frequency of either 120 or 240 Hz with a small displacement of 0.030 to 0.140 inch (0.7 to 3.5 mm).

In this process, one part is fixed in a stationary head, while the second part, attached to a welding head, vibrates on the joint plane. Pressing the two parts' surfaces together at a pressure of 200 to 245 psi (1.4 to 1.7 MPa) and vibrating one against the other generates heat.

When the joint interface reaches a molten state, the vibrating action is stopped, parts are aligned, and clamp pressure is briefly applied. Overall cycle times for vibration welding are usually 4 to 15 seconds (see figures 30, 31, 32 and 33 for joint designs).

## SPIN WELDING

You can weld round parts using spin welding. Often a tongue-and-groove joint design is used to align the two parts and provide a uniform bearing surface.

In spin welding, one part remains stationary, while the other rotates at 300 to 500 rpm. Pressure applied during the welding cycle keeps the parts in contact with each other. Friction-generated heat brings the surfaces to sealing temperature, which varies with each resin. For example, this temperature is approximately 425°F (220°C) for Makrolon polycarbonate resins. After getting sufficient melt, the rotation is stopped and the pressure is increased to distribute melted material and complete the bonding process.

To counteract inertial forces in some cases, the stationary part is allowed to rotate with the moving part after the mating surfaces have melted.

*Solvent and adhesive bonding are probably the least expensive joining methods for permanent bonds. Solvent bonding joins one plastic to itself or another type of plastic that dissolves in the same solvent. Typically, this process involves treating the bonding area with the minimum amount of solvent needed to soften the surfaces, then clamping the parts together until they bond. Adhesive bonding uses commercially available materials that are specifically formulated to bond plastic parts to themselves or other substrates. This section discusses common bonding methods and practices associated with these joining techniques.*

## SOLVENTS

*Polycarbonate and Polycarbonate Blends*

Suitable bonding solvents vary with resin. You can bond parts made of Makrolon polycarbonate and/or Bayblend resins using methylene chloride or ethylene dichloride. Methylene chloride's fast evaporation rate helps to prevent solvent-vapor entrapment for simple assemblies (see figure 34). For complex assemblies that require more curing time, use ethylene dichloride, because it has a slower evaporation rate, allowing for longer assembly times. Mixing methylene chloride and ethylene dichloride in a 60/40 solution, a commonly used mixture, will give you a longer time to assemble parts than pure methylene chloride because of the reduced evaporation rate.

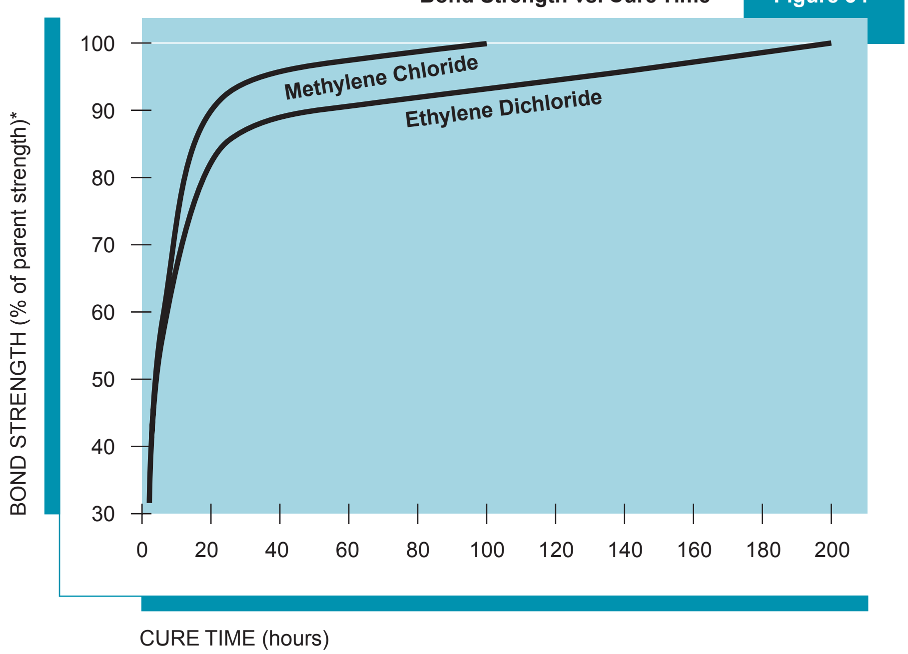
When using solvent-bonding techniques with these resins, some embrittlement may occur. Parts can lose some of their excellent impact strength at the weld joint.

*Safe Solvent Handling*

**Be careful when using any of these solvents. You must refer to your solvent supplier's Material Safety Data Sheet for health and safety information and appropriate handling recommendations, including the use of proper protective equipment, for all of the solvents discussed in this section.**

Bond Strength vs. Cure Time

Figure 34




Cure curves for Makrolon 2608 resin @ 10/60 sec setup/clamp, 100 psi, lap-shear test.

**Parent strength is yield strength of the base resin.*

A five to ten percent solution of polycarbonate in methylene chloride helps to produce a smooth, filled joint when the mating parts made of Makrolon resin or Bayblend PC/ABS resin do not fit perfectly. Do not use this mixture to compensate for severely mismatched joints. Increasing the concentration can result in bubbles at the joint.

### *Makroblend Resins*

Do not use solvent bonding with parts made of Makroblend resins. Because of Makroblend's polyester component and the resulting high chemical resistance, aggressive solvents must be used for bonding. These solvents can cause low bond strength.

### *Polyamide and PA Blends*

Parts made of polyamide 6 resins can be solvent bonded using solutions of concentrated formic acid, alcoholic calcium chloride, concentrated aqueous chloral hydrate, or concentrated alcoholic phenol and resorcinol. Adding five to ten percent by weight of unreinforced polyamide resin makes the solvents easier to use. In optimum bonding conditions, the bond strength after bonding approaches the resin's normal strength.

### *Thermoplastic Elastomers*

Parts made of Texin or Desmopan thermoplastic polyurethanes can be bonded to themselves and other substrates with dimethyl formamide (DMF) or tetrahydrofuran (THF).

### *Styrenics*

Parts made of ABS, SAN and ASA polymers can be solvent bonded using similar procedures and different solvents. Typically, use methylethylketone (MEK), acetone, or a mixture of the two. Additionally, a paste made of MEK and the base resin can be used to fill small gaps in a part or assembly.

### *Safe Solvent Handling*

**Be careful when using any of these solvents. You must refer to your solvent supplier's Material Safety Data Sheet for health and safety information and appropriate handling recommendations, including the use of proper protective equipment, for all of the solvents discussed in this section.**

## BONDING PROCEDURES

Mating surfaces should be cleaned and free of grease, dirt or foreign matter before bonding. For optimum bonding, parts should be well mated with no strains to ensure uniform pressure distribution across the entire bond area.

Use a minimum amount of solvent. For best results, only one surface needs to be wet. Excessive solvent can cause bubbling and "squeeze out," decreasing the bond strength.

Apply a thin film of solvent to one part only. Within a few seconds after applying the solvent, clamp parts together in a pressure fixture applying between 100 and 500 psi for a minimum of 60 seconds.

Because ultimate bond strength is primarily a function of solvent concentration on mating surfaces, control the elapsed time between application and clamping carefully. If too much evaporation occurs before clamping, poor bonding will result. For critical applications needing more durability, consider adhesive bonding.

## CURING SOLVENT-BONDED PARTS

Cure parts molded from Makrolon resin bonded with methylene chloride that are ultimately intended for room-temperature service for 24 to 48 hours in a well-ventilated area at room temperature. Never cure these parts in an air-tight enclosure where solvent vapors may be trapped. These vapors could attack parts and embrittle them.

Tests done at Covestro indicate that methylene-chloride-bonded parts had 80 to 90 percent of the ultimate bond strength after curing for one to two days (see figure 34).

**Table 5** Solvent Bond Curing Schedule

| Sequential Holding Time | Part or Bond Temperature |
|---|---|
| 8 hr | 73°F (23°C) |
| 12 hr | 100°F (40°C) |
| 12 hr | 150°F (65°C) |
| 12 hr | 200°F (93°C) |
| 12 hr | 225°F (110°C) |

When working with polycarbonate resins and blends, curing parts for elevated-service use and maximum bond strength is much more complicated. You may have to use a complicated treatment schedule of gradually increasing temperatures for these applications (see table 5). For example, if an assembly is going to operate in an ambient temperature of 200°F (93°C), the bonded parts should be cured at 73°F (23°C) for eight hours; then at 100°F (38°C) for 12 hours, 150°F (65°C) for 12 hours, and finally 200°F (93°C) for 12 hours. Smaller bond areas can cure in shorter times, while large areas usually require longer times or smaller temperature intervals.

Uncured parts suddenly exposed to elevated-temperature service can suffer complete joint failure. Generally, the highest cure temperature should be equal to or slightly higher than the highest expected service temperature.

## ADHESIVE BONDING SYSTEMS

Adhesive bonding systems are among the most versatile for joining plastic parts to parts made of the same plastic, a different plastic or a non-polymeric substrate. Generally, adhesives produce more consistent and predictable results in joints requiring strength and durability than other joining methods. The wide variety of modern adhesives ensures that you can find an optimum system for your application.

A number of variables must be considered when selecting adhesive bonding materials, including:

- Chemical compatibility with the plastic substrate;
- Flexibility/rigidity requirements;
- Environmental and temperature requirements; and
- Aesthetics.

Generally, two-part epoxy and urethane adhesives impart excellent bond strength for thermoplastic materials. Cyanoacrylate-based adhesives can produce quick bonds; however, cyanoacrylates can be aggressive when used with polycarbonate resins, especially if parts have high levels of molded-in and/or applied stresses. Additionally, cyanoacrylic adhesive can be brittle. If your part will be subjected to bending loads at the joint, you may want to select a more ductile system.

UV-cured adhesives, excellent for transparent materials such as Makrolon polycarbonate and SAN, cure in seconds and typically have high bond strength. Two-part acrylic adhesives usually show high bond strength. Use care in selecting these adhesives, as some of their accelerators can be very aggressive to Makrolon polycarbonate and Bayblend resins (see table 6).

Table 7 lists the relative bond strengths for four commercially available adhesives and one solvent for medical-grade Texin 5000-series thermoplastic polyurethanes (TPU) bonded to various plastics. Mating substrates included flexible and rigid PVCs, thermoplastic polyurethanes, acrylic, and polycarbonate resins.

Prototype-test all parts to determine a given adhesive's suitability.

*Safe Adhesive Handling*

**You must refer to your adhesive supplier's Material Safety Data Sheet for health and safety information and appropriate handling recommendations, including the use of proper protective equipment, for any bonding system that you use.**

**Table 6** **Adhesive Systems Suitable for Bonding Covestro Thermoplastics**

| Type of Adhesive | Suppliers | Resins | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Apec | Bayblend | ASA | Polyamides | ABS | SAN | Makroblend | Makrolon | Texin | PA/ABS Blend |
| **Epoxy (Two-Part)** | A, B | ● | ● | ● | ● | ● | ● | ● | ● | N/A | ● |
| **Urethane (Two-Part)** | C, D, E, H, K | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| **Cyanoacrylate** | B, F | ■ | ■ | ● | ● | ● | ● | ■ | ■ | ● | ● |
| **Acrylic** | H | ● | ● | ● | N/A | ● | ● | ● | ● | ● | ● |
| **Methacrylic** | M | ● | ● | ● | N/A | ● | ● | ● | ● | ● | ● |
| **Silicone** | G | ● | ◆ | ◆ | ● | ◆ | ◆ | ● | ● | ● | ◆ |
| **UV Cure** | B, I | ● | N/A | N/A | N/A | N/A | ● | N/A | ● | ● | N/A |
| **Hot Melt** | F, N | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| **LIQUID NAILS®** | L | X | X | ● | ● | ● | ● | X | X | X | ● |
| **Vinyl** | J | ● | ● | ● | ● | ● | ● | ● | ● | ● | N/A |
| **Contact Tape** | A | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |

● Suitable adhesives

■ Some cyanoacrylates can be aggressive to polycarbonate and PC blends, and some cure to a brittle layer which can significantly lower the flexural and impact properties of the substrate

◆ Acetoxy-cure silicones can be aggressive to styrenics and styrenic blends if the acetic acid fumes are trapped in the joint

X Cannot be used with resins containing polycarbonate

**A.** 3M Industrial Specialties
St. Paul, MN 55144
(612) 733-1110
*Epoxies, Contact Tape, Contact Adhesives*

**B.** Loctite Corporation
Rocky Hill, CT 06067
(860) 571-5100
*Epoxies, Cyanoacrylates, UV Cure*

**C.** Ciba-Geigy Corporation
East Lansing, MI 48823
(800) 875-1363
*Urethanes*

**D.** Ashland Chemicals
Columbus, OH 43216
(614) 790-3639
*Urethanes*

**E.** Lord Corporation
Erie, PA 16514
(814) 868-3611
*Urethanes*

**F.** Bostik
Middleton, MA 01949
(508) 777-0100
*Hot Melts, Cyanoacrylates*

**G.** GE Silicones
Waterford, NY 12188
(518) 237-3330
*Silicones*

**H.** Ciba Furane Products
Los Angeles, CA 90039
(818) 247-6210
*Acrylics, Urethanes*

**I.** Dymax Corporation
Torrington, CT 06790
(203) 482-1010
*UV Cures*

**J.** King Adhesive Corporation
St. Louis, MO 63110
(314) 772-9953
*Vinyls*

**K.** Morton International Inc.
Chicago, IL 60606-1598
(312) 807-3218
*Urethanes*

**L.** The Glidden Company
Cleveland, OH 44115
(216) 344-8000
*LIQUID NAILS®*

**M.** ITW Adhesives Systems
Danvers, MA 01923
(800) 851-6692
*Methacrylics*

**N.** Henkel Adhesives
LaGrange, IL
60525-3602
(708) 579-6150
*Hot Melts*

**Table 7** **Relative Bond Strength of Several Thermoplastic Materials to Medical Grade Texin Thermoplastic Polyurethanes**

| Material | Solvent or Adhesive (from highest to moderate bond strength) |
|---|---|
| **Flexible PVC to Texin TPU resin** | Dimethyl Formamide (DMF Solvent) |
| | Solvent-Based Urethane (Bostik 7133 Adhesive) |
| | UV-Curable (Dymax 190-M Adhesive) |
| | Cyanoacrylate (Loctite P-454 Adhesive) |
| | UV-Curable (Dymax 181-M Adhesive) |
| **Rigid PVC to Texin TPU resin** | Dimethyl Formamide (DMF Solvent) |
| | Solvent-Based Urethane (Bostik 7133 Adhesive) |
| | UV-Curable (Dymax 181-M Adhesive) |
| | UV-Curable (Dymax 190-M Adhesive) |
| | Cyanoacrylate (Loctite P-454 Adhesive) |
| **Acrylic to Texin TPU resin** | Dimethyl Formamide (DMF Solvent) |
| | Solvent-Based Urethane (Bostik 7133 Adhesive) |
| | UV-Curable (Dymax 181-M Adhesive) |
| | Cyanoacrylate (Loctite P-454 Adhesive) |
| **Polycarbonate to Texin TPU resin** | UV-Curable (Dymax 190-M Adhesive) |
| | Solvent-Based Urethane (Bostik 7133 Adhesive) |
| | UV-Curable (Dymax 181-M Adhesive) |
| | Dimethyl Formamide (DMF Solvent) |
| | Cyanoacrylate (Loctite P-454 Adhesive) |
| **Texin TPU to Texin TPU resin** | Dimethyl Formamide (DMF Solvent) |
| | Solvent-Based Urethane (Bostik 7133 Adhesive) |
| | UV-Curable (Dymax 190-M Adhesive) |
| | UV-Curable (Dymax 181-M Adhesive) |
| | Cyanoacrylate (Loctite P-454 Adhesive) |
| **Polycarbonate to Polycarbonate** | Dimethyl Formamide (DMF Solvent) |
| | UV-Curable (Dymax 181-M Adhesive) |
| | UV-Curable (Dymax 190-M Adhesive) |
| | Cyanoacrylate (Loctite P-454 Adhesive) |
| | Solvent-Based Urethane (Bostik 7133 Adhesive) |

For more information on these products, please contact the following suppliers:

**Dimethyl Formamide Solvent (DMF)**
Fisher Scientific
585 Alpha Drive
Pittsburgh, PA 15222
(412) 963-3300

**Solvent-Based Urethane Adhesive (B-7133)**
Bostik, Inc.
211 Boston Street
Middleton, MA 01949
(508) 777-0100

**Prism Cyanoacrylate Adhesive (P-454)**
Loctite Corporation
705 N. Mountain Road
Rocky Hill, CT 06067
(860) 571-5100

**UV-Curable Adhesive (181-M) and (190-M)**
Dymax Corporation
51 Greenswood Road
Torrington, CT 06790
(860) 482-1010

# TECHNICAL SERVICES

## DESIGN AND ENGINEERING EXPERTISE

To get material selection and/or design assistance, contact your Covestro representative.

.To better help you, we will need to know the following information:

- Physical description of your part(s) and engineering drawings, if possible
- Current material being used
- Service requirements, such as mechanical loading and/or strain, peak and continuous service temperatures, types of chemicals to which the part(s) may be exposed, stiffness required to support the part itself or another item, impact resistance, and assembly techniques
- Applicable government or regulatory agency test standards
- Tolerances that must be held in the functioning environment of the part(s)
- Any other restrictive factors or pertinent information of which we should be aware

Upon request, Covestro will furnish such technical advice or assistance it deems to be appropriate in reference to your use of our products. It is expressly understood and agreed that because all such technical advice or assistance is rendered without compensation and is based upon information believed to be reliable, the customer assumes and hereby releases Covestro from all liability and obligation for any advice or assistance given or results obtained. Moreover, it is your responsibility toconduct end-use testing and to otherwise determine to your own satisfaction whether Covestro's products and information are suitable for your intended uses and applications.

## TECHNICAL SUPPORT

We provide our customers with design and engineering information in several ways: Applications advice, available through your Covestro representative; processing assistance, through a nationwide network of regional field technical service representatives; technical product literature; presentations and seminars.

# TECHNICAL SERVICES

The types of expertise you can obtain from Covestro include:

**Design Review Assistance**

- Concept development
- Product/part review
- Tooling review
- Material selection
- Finite element analysis
- Mold filling analysis
- Structural stress analysis

**Application Development Assistance**

- Product development
- Color matching
- Prototyping
- Part failure analysis
- Molding trials
- Physical testing
- Secondary operation advice

**Product Support Assistance**

- Dryer audits
- On-site processing audits
- Start-up assistance
- On-time material delivery
- Troubleshooting
- Processing/SPC Seminars
- Productivity audits

## REGULATORY COMPLIANCE

Some of the end uses of the products described in this publication must comply with applicable regulations, such as the FDA, USDA, NSF, and CPSC. If you have any questions on the regulatory status of these products, contact your Covestro representative or the Regulatory Affairs Manager in Pittsburgh, Pa.

## HEALTH AND SAFETY INFORMATION

Appropriate literature has been assembled which provides information concerning the health and safety precautions that must be observed when handling Covestro thermoplastic resins mentioned in this publication. Before working with any of these products, you must read and become familiar with the available information on their hazards, proper use, and handling. This can not be overemphasized. Information is available in several forms, e.g., material safety data sheets and product labels. Consult your Covestro representative or contact the Product Safety Manager for Polymers Division products in Pittsburgh, Pa.

## FOR MORE INFORMATION

The data presented in this brochure are for general information only. They are approximate values and do not necessarily represent the performance of any of our materials in your specific application. For more detailed information, go to www.plastics.covestro.com or contact your Covestro sales representative.

## NOTES

The manner in which you use and the purpose to which you put and utilize our products, technical assistance and information (whether verbal, written or by way of production evaluations), including any suggested formulations and recommendations, are beyond our control. Therefore, it is imperative that you test our products, technical assistance, information and recommendations to determine to your own satisfaction whether our products, technical assistance and information are suitable for your intended uses and applications. This application-specific analysis must at least include testing to determine suitability from a technical as well as health, safety, and environmental standpoint. Such testing has not necessarily been done by Covestro.

Unless we otherwise agree in writing, all products are sold strictly pursuant to the terms of our standard conditions of sale which are available upon request. All information and technical assistance is given without warranty or guarantee and is subject to change without notice. It is expressly understood and agreed that you assume and hereby expressly release us from all liability, in tort, contract or otherwise, incurred in connection with the use of our products, technical assistance, and information. Any statement or recommendation not contained herein is unauthorized and shall not bind us. Nothing herein shall be construed as a recommendation to use any product in conflict with any claim of any patent relative to any material or its use. No license is implied or in fact granted under the claims of any patent.

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